

1b. RESTRICTIVE MARKINGS 3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited. 4. PERFORMING ORGANIZATION REPORT NUMBER(S) 5. MONITORING ORGANIZATION REPORT NUMBER(S) 64. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 64. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 65. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 86. NAME OF FUNDING/SPONSORING ONGANIZATION U. S. Army Research Office 86. OFFICE SYMBOL (If applicable) DUKE UNIVERSITY 76. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 77. NAME OF FUNDING NUMBERS DAALO 3 - 86 - 6 - 00 46 86. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 10. SOURCE OF FUNDING NUMBERS PROGRAM PROJECT TASK NO. MORK UNIT ACCESSION 12. PERSONAL AUTHOR(S) Phillip L. Jones 136. TYPE OF REPORT TO BE THE OFFICE OF THE OFFICE OF THE OFFICE O	0.
Approved for public release; distribution unlimited. 4. PERFORMING ORGANIZATION REPORT NUMBER(S) 5. MONITORING ORGANIZATION REPORT NUMBER(S) 64. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 65. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 86. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 86. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 86. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 10. SOURCE OF FUNDING NUMBERS PROGRAM PROJECT PROGRAM PROJECT PROGRAM PROJECT PROM PROJECT PROM PROJECT PROM PROJECT PROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) PS. PAGE COUNT Final 15. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are thos of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUPPLEMENTANS (Contained in this report are thos of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUPPLEMENTANS (Contained in this report are thos of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUPPLEMENTS (Contained in this report are thos of the author of the Army position.	000
distribution unlimited. 4. PERFORMING ORGANIZATION REPORT NUMBER(S) 5. MONITORING ORGANIZATION REPORT NUMBER(S) 64. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 65. OFFICE SYMBOL (If applicable) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 66. OFFICE SYMBOL (If applicable) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 68. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 69. O. Box 12211 Research Triangle Park, NC 27709-2211 10. SOURCE OF FUNDING NUMBER PROJECT TASK NO. WORK UNIT Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 10. SOURCE OF FUNDING NUMBERS PROJECT TASK NO. WORK UNIT FINAL TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 136. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army positi 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	C. M. C.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 5. MONITORING ORGANIZATION REPORT NUMBER(S) ALO 2379/.2-MS-R 4. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 6. ADDRESS (Cry, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8. NAME OF FUNDING SPONSORING ORGANIZATION U. S. Army Research Office 8. ADDRESS (Cry, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8. ADDRESS (Cry, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. PROJECT Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 1989, November 16 15. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position. 15. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position. 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Cordinae on reverse if necessary and identify by block number)	060 mm
6a. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 6c. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Triangle Park, NC 27709-2211 Research Triangle Park, NC 27709-2211 8b. OFFICE SYMBOL (If applicable) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT (13b. Time Covered From 9-1-86 to 8-31-89) 14. DATE OF REPORT (veer, Month, Day) 15. PAGE COUNT Final The Covered From 9-1-86 to 8-31-89 (1989, November 16) 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are thos of the author(s) and should not be construed as an official Department of the Army positing the supplement of the Army positing the supplementary and identify by block number) 17. COSATICODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	S. C.
68. NAME OF PERFORMING ORGANIZATION DUKE UNIVERSITY 6. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8b. OFFICE SYMBOL (If applicable) P. O. Box 12211 Research Triangle Park, NC 27709-2211 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAALO3 - 86-6-0046 8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) PAGE COUNT Final 15. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army positing to the construed of the Army positing the content of the Army positing to the construed of the Army positing the content of the Army p	0.
DUKE UNIVERSITY 6. ADDRESS (Cry. State, and ZiP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Triangle Park, NC 27709-2211 8. OFFICE SYMBOL (If applicable) P. O. Box 12211 Research Triangle Park, NC 27709-2211 10. SOURCE OF FUNDING NUMBER PROGRAM ELEMENT NO. 11. TITLE (Include Security Classification) Phillip L. Jones 12. PERSONAL AUTHOR(S) Phillip L. Jones 13. TYPE OF REPORT FINAl FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) FROM 9-1-86 TO 8-31-89 15. SUPPLEMENTARY NOTATION of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	0
Sc. ADDRESS (City, State, and ZIP Code) Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) FROM 9-1-86 TO 8-31-89 15. SUPPLEMENTARY NOTATION Of the author(s), and should not be construed as an official Department of the Army position of the author of decision unless to designate at his object received and official Department of the Army position of the author of decision unless to designate at his construed as an official Department of the Army position of the Subject Termis (Continue on reverse if necessary and identify by block number)	0.
Department of Mechanical Engineering and Materials Science/Duke University Durham, NC 27706 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED PROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) Phillip L. Jones 15. PAGE COUNT Final 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author of the Army position of the Subject TeRMS (Continue on reverse if necessary and identify by block number)	O.
and Materials Science/Duke University Durham, NC 27706 8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14b. DATE OF REPORT (Year, Month, Day) From 9-1-86 TO 8-31-89 16b. SUPPLEMENTARY NOTATION Of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the author of the Army position	o.
Burham, NC 27706 Ba. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office Bc. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the Army position of the Army position of the Supplementary and identify by block number)	0.
ORGANIZATION U. S. Army Research Office BC. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT From 9-1-86 TO 8-31-89 16. SUPPLEMENTARY NOTATION Of the author(s) and should not be construed as an official Department of the Army position of the author(s) and should not be construed as an official Department of the Army position of the Supplement Structure of the Army position of the Supplement Structure of the Army position of the Army position of the Supplement Structure of the Army position of the Army position of the Supplement Structure of the Army position of the Supplement Structure of the Army position of the Supplement Structure of the Army position of the	o .
U. S. Army Research Office BC ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final PROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) FROM 9-1-86 TO 8-31-89 15. PAGE COUNT Final The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army positing the covered of the author of the Army positing the contained of the contained of the Army positing the contained of the	O.
P. O. Box 12211 Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be constructed as an official Department of the Army positi 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	o .
Research Triangle Park, NC 27709-2211 11. TITLE (Include Security Classification) Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT Final 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the Order Science of the Army position of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	o .
11. TITLE (Include Security Classification) Positron Annihilation Spectroscopy: A Nondestructive, Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT Final 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army positi 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT FROM 9-1-86 TO 8-31-89 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the supplementation. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
Submicroscopic Characterization Technique for Structural Polymers. (unclassified) 12. PERSONAL AUTHOR(S) Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT FROM 9-1-86 TO 8-31-89 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the supplementation. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
Phillip L. Jones 13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT Final 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
13a. TYPE OF REPORT Final 13b. TIME COVERED FROM 9-1-86 TO 8-31-89 14. DATE OF REPORT (Year, Month, Day) 15. PAGE COUNT 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
Final FROM 9-1-86 TO 8-31-89 1989, November 16 16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position of the Army position of the Army position. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
16. SUPPLEMENTARY NOTATION The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position unless so designated by other documentation. 17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
of the author(s) and should not be construed as an official Department of the Army positing the process of the Army positing the construction of the const	
17. COSATI CODES 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	n,
E I LICE I COMPANDA DE LA COMPANDA DEL COMPANDA DE LA COMPANDA DEL COM	
FIELD GROUP SUB-GROUP Positron Annihilation Lifetime Spectroscopy, Polycarbonate, Physical Aging, Structural Relaxation	
Polycarbonate, Physical Aging, Structural Relaxation	
19. ABSTRACT (Continue on reverse if necessary and identify by block number)	
Positron annihilation lifetime spectroscopy (PALS) has been used to characterize	
as extended and aged (EYAN polycarbonate. The long-lived component of the PALS	
analysis is attributed to orthopositronium (OPS) DICK OTT diminilations. The ora	
nickoff component lifetime and intensity decrease as the result of the dying heat	
treatment, and this decrease is associated with a decrease in the free volume site	
size and concentration in glassy polycarbonate due to aging. Isothermal relaxation experiments performed over the range 12°C to 30°C performed on as-extruded and aged	
I relucembenate indicate that the relaxation kinetics are significable uniterent, and	
I are consistent with a decrease in molecular modellaty as the result of aging, An	
activation energy for structural relaxation of 8.2 KCal/Mole for aged polycarbonate	
was determined. The related noivearbonate was determined. The related	
kinetics observed using PALS is related to the structural state and molecular	
mobility of the polymer. 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT 21. ABSTRACT SECURITY CLASSIFICATION	
□UNCLASSIFIED/UNUMITED □ SAME AS RPT. □ DTIC USERS Unclassified	
228. NAME OF RESPONSIBLE INDIVIDUAL 22b. TELEPHONE (Include Area Code) 22c. OFFICE SYMBOL	

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

90 01

190



<u>Proposal Number</u>: 23791-MS <u>Funding Document</u>: DAAL-86-G-0046

Statement of the Problem Studied

Positron annihilation lifetime spectroscopy (PALS) has been used to study the mechanism of physical aging in polycarbonate. The PALS analysis was supplemented with tensile testing, differential scanning calorimetry, density measurements and x-ray diffraction.

Summary of Findings

The results of this investigation have led to the following conclusions:

- 1. Physical aging of polycarbonate increases the relaxation times of ortho-positronium (o-Ps) pickoff intensity I₃ during free volume recovery. This increase in relaxation time is a reflection of the increase in molecular response times due to physical aging, which is also evident in the changes in tensile and physical properties (increased yield strength, post yield stress drop, glass transition temperature and density).
- 2. The time rate of change observed in I₃ during contraction and expansion experiments in glassy polycarbonate is of the same form as volume and enthalpy recovery, and can be modeled similarly.
- 3. Any change in molecular conformation during physical aging is not evident in the o-Ps pickoff lifetime or intensity. Thus, the physical aging phenomena is not the result of a decrease in the amount of free volume or mean free volume cavity size.
- 4. The physical aging mechanism in polycarbonate is postulated to be associated with either an increase in entanglement density, an increase in the population of trans conformations, or a combination of both.
- 5. Over the temperature range 20°C to 120°C the o-Ps pickoff lifetimes and intensities are lower in aged polycarbonate than in as-

extruded polycarbonate, which is interpreted as a decrease in free volume concentration and cavity size as the result of physical aging.

- 6. The change in I₃ measured during isothermal relaxation experiments for both as-extruded and physically aged polycarbonate can be substituted for the fractional free volume in various theories used to model viscoelastic behavior of glassy polymers.
- 7. The nondestructive character and relative ease of data collection associated with positron annihilation lifetime spectroscopy could make this technique important in the prediction of physical property response in glassy polymers.

Publications

- 1. P.L. Jones, A.J. Hill, G.W. Pearsall and J.H. Lind, "A Positron Annihilation Lifetime Study of Poly(Bisphenol-A Carbonate)", Materials Research Society Symposium Proceedings, 82 (1987) 29-34.
- 2. A.J. Hill, P.L. Jones, J.H. Lind and G.W. Pearsall, "A Positron Annihilation Lifetime Study of Isothermal Structural Relaxation in Bisphenol-A Polycarbonate", <u>Journal of Polymer Science</u>, <u>A</u>, <u>26</u> (1988) 1541-1549.
- 3. A.J. Hill, K.J. Heater and C.M. Agrawal, "The Effects of Physical Aging in Polycarbonate", <u>Journal of Polymer Science</u>, (accepted June 1989).

Scientific Personnel

- 1. Phillip L. Jones, Associate Professor of Materials Science, Department of Mechanical Engineering and Materials Science, Duke University, Durham, North Carolina, 27706.
- 2. Anita J. Hill, graduate student (M.S., December 1986 and Ph.D., May 1989)